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MYRIOPHYLLUM MATTOGROSSENSE (HALORAGACEAE), A RARE LOWLAND WATERMILFOIL NEW TO BOLIVIA

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ABSTRACT. *Myriophyllum mattogrossense* is reported as new to Bolivia. This rare Watermilfoil of the Amazon Basin was previously known only from the original area of discovery in Brazil, one locality in the lowlands of Peru, and one in Ecuador. Notes on morphology, including a terrestrial growth form, and habitat are given, and a key is provided to differentiate the South American taxa of *Myriophyllum*.

Key Words: *Myriophyllum*, Haloragaceae, Watermilfoil, Bolivia

Since 1994 we have been conducting a broad biodiversity survey of aquatic and wetland plants in Bolivia. While carrying out this fieldwork we encountered two small populations of *Myriophyllum* growing in streams ca. 20 km apart in the Amazon Basin region of Bolivia, known as the Chapare. The plants were found growing in swiftly flowing water of small rapids, rooted among rocks and gravel. These plants were conspicuously different from *M. quitense* Kunth (= *M. elatinoides* Gaud.), the common and widely distributed species in Bolivia. Although *M. quitense* is a common element of high elevation lakes, and is often so abundant that cattle are driven into the water to feed on it during the dry season (Dejoyx and Iltis 1991; Ritter and Crow 1998), we had not found any other populations below 2500 m and were surprised to encounter a *Myriophyllum* in the lowlands. Another species of *Myriophyllum, M. aquaticum* (Vell.) Verdc. (= *M. brasiliensis* Camb.), is a widespread aquatic weed of tropical and warm temperate regions, including northern Argentina, Paraguay, and southern Brazil (Orchard, 1981). However in Bolivia, this species is known only from a newly discovered site in the Interandean Valley Region (Ritter and Crow, in press), and it was obvious that our material was distinct from *M. aquaticum*.

We were ultimately able to determine the identity of the plant in the Chapare as *Myriophyllum mattogrossense* Hoehne, the first record known for Bolivia. Until recently, this rare species had been known only from two locations, one near Cuyabá, Mato

Grosso, Brazil, upon which F. C. Hoehne (1915) based the description for his new species, and one in the foothills on the eastern side of the Andes at Tocache Nuevo, Peru (Kahn et al. 1993; Orchard 1981). More recently, *M. mattogossense* was collected from a third location, near Coca, Ecuador (Orchard and Kasselmann 1992). Orchard (1981) noted that the species might well be found eventually in a much wider area of the lower foothills on the eastern side of the Andes of Peru, Brazil, and perhaps even Bolivia, and attributed the lack of known sites to the submerged habit and inconspicuous flowers.

Moreover, it is our experience that aquatic plants, in general, are greatly undercollected in the Neotropics. Many aquatic plants which are rather common are poorly represented in herbaria. Additional populations of *Myriophyllum mattogrossense* surely exist, but are not likely to be encountered unless the fieldwork is specifically focused on aquatic plants. This was certainly the case when Christel Kasselmann, a specialist of aquatic plants for aquarium culture, collected the first record for Ecuador (Orchard and Kasselmann 1992). We stumbled onto the first Bolivian population while searching for members of the Podostemaceae, an aquatic family restricted to rapids and swift flowing waters in areas with a seasonal fluctuation of water levels. Thus, *M. mattogrossense* is now known from its type locality in Mato Grosso, Brazil, and in the Amazon Basin near the base of the Andes in Ecuador, Peru, and Bolivia (Figure 1).

The Chapare region, where the Bolivian populations were encountered, borders the eastern slope of the Andes and is notable for having the highest amount of rainfall in Bolivia, with parts of the region receiving more than 5000 mm of precipitation per year (Ribera et al. 1994). The larger rivers and tributaries of the area experience a high level of disturbance during the rainy season. River courses in the Chapare are extremely transitory, with riverbeds receiving large depositions of gravel and sand, and with new channels frequently being formed while former stretches are transformed into *curiches* (oxbows). Streams and other tributaries can also experience significant disturbance as well. Generally speaking, the streams in the area are characterized by a lack of rooted vegetation and haptophytes (Crow and Ritter, pers. obs.). In the case of *Myriophyllum mattogrossense,* it appears that a combination of fairly specific habitat requirements—clear, fast-moving water and a substrate composed of gravel and cobbles—

Figure 1. Documented distribution of *Myriophyllum mattogrossense*.

coupled with the transitory nature of aquatic habitats due to severe disturbances, serves to limit the number of populations of this species.

Previously, this species was believed to be strictly submersed. Orchard (1981) stated that the species is unusual in that its flowers and fruits are unusually small, and that the plant was reported to grow completely submersed, resulting in underwater opening and pollination of the flowers. While we observed the submersed

plants to be fertile, as did Hoehne (1915), we also observed the existence of a terrestrial growth form for *Myriophyllum mattogrossense,* likewise in fertile condition. The terrestrial growth form was initiated as the water level dropped and marginal plants became stranded (Figure 2). The submersed leaves dried up and new upright branches sprouted from the prostrate stem. When seen in this condition, the species had an almost moss-like, or *Hippurus*-like appearance (Figure 2). Although this was observed in both of the Bolivian populations, there was no mention of a terrestrial growth form on the labels of the Peruvian specimens examined. However, Kasselmann (Orchard and Kasselmann 1992) observed emergent plants growing on mud along the riverbank, which fit the description of the terrestrial growth form we observed.

In the Bolivian material the leaves of submersed plants have segments that, while filiform, are very thin, distinctly flattened, with a conspicuous midvein, and which are wider than typical for *Myriophyllum quitense.* The Peruvian material examined exhibited the same morphology. We were able to examine only one herbarium specimen of the Ecuadorian material, and while the submersed leaves were flattened, the segments were much more filiform than those of either the Bolivian or Peruvian material. However, they did closely resemble those depicted in the illustration accompanying Hoehne's (1915) original description, now serving as the lectotype (Orchard 1981). Previously, we had noted that the markedly capillary leaf segments in the Brazilian population were altogether distinct from those of the other populations. We were able to reconcile this variation by attributing it to habitat differences (*lacus temporarius* in Brazil). Arber (1920) noted that water plants respond to certain physical stimuli and that in *Myriophyllum,* in particular, one can observe marked differences in the morphology of the same species growing in different current regimes. In still water, plants may have leaf segments that are delicate and nearly hair-like, while the stresses of current on the leaves of plants growing in strongly flowing water require that leaves tend toward increased mass and thickness (Arber 1920; Gerber and Les 1994).

In contrast to the submersed plants, the leaves of the terrestrial form have divisions that, while still somewhat flat, are pectinate (with fewer divisions), thicker, and distinctly succulent (Figure

Figure 2. Habit of terrestrial growth form of *Myriophyllum mattogrossense* at edge of stream.

Figure 3. Close-up view of terrestrial growth form of *Myriophyllum mattogrossense* showing somewhat flattened, thicker, succulent, pectinate leaves.

3). The flowers and fruits are axillary on both terrestrial and submersed plants.

DESCRIPTION OF BOLIVIAN MATERIAL

Plants perennial, herbaceous aquatics, with submerged and terrestrial growth forms (Figure 4). Stems and leaves with small sessile glands; glands moderately dense on young growth, becoming sparse on older growth. Submersed growth form: stems flexuous, ascending in quiet water, somewhat horizontal in flowing water; leaves verticillate, in whorls of 3–4, pinnately divided, ca. (18–)20–22(–25) mm long, with 7–8 pairs of lateral segments (mostly alternate), segments flattened, 0.4–0.5 mm wide, each with a distinct midvein; hydathodes filiform, tiny, present at base of petioles and each leaf segment on young growth. Terrestrial growth form: stems of submersed plants rooting on stream margins or gravel bars, submersed leaves withering away; upright stems arising from axillary buds, not flexuous, sturdy, erect; leaves verticillate, pectinate, mostly 10–11 mm long, becoming shorter toward stem tip (4–5 mm long), mostly with 3 pairs of lateral segments (alternate), segments somewhat flattened, thickish, slightly succulent, each with a distinct midvein (especially on herbarium material) each segment with an apical secretory gland; hydathodes filiform, tiny, present at base of petioles and each leaf segment on young growth. Flowers (both growth forms) axillary, 1–4 per whorl, bisexual, appearing sessile (pedicel short, 0.25–0.4 mm long), subtended by a pair of bracteoles (apparently early caducous), frequently with filiform hydathodes on each. Perianth 4-merous, opposite the ovary lobes, alternate with stamens. Stamens 4, subsessile, anthers ovoid, slightly apiculate at tip, stamens developing before stigmas, not long persisting. Ovary inferior, 4-lobed, stigmas 4, conical; tiny hydathodes present at summit of ovary. Fruits globose, 4-lobed, 7–9 mm long, 7–9 mm wide; mericarps with a few weak tubercles on outer surface.

Flowering in this species did not appear to be seasonal. Based on all specimens examined, flowering material has been observed on specimens collected in February, March, April, May, June, and November.

Orchard and Kasselmann (1992) noted a number of features evident in the Ecuadorian populations which had not previously been observed in *Myriophyllum mattogrossense,* thus expanding

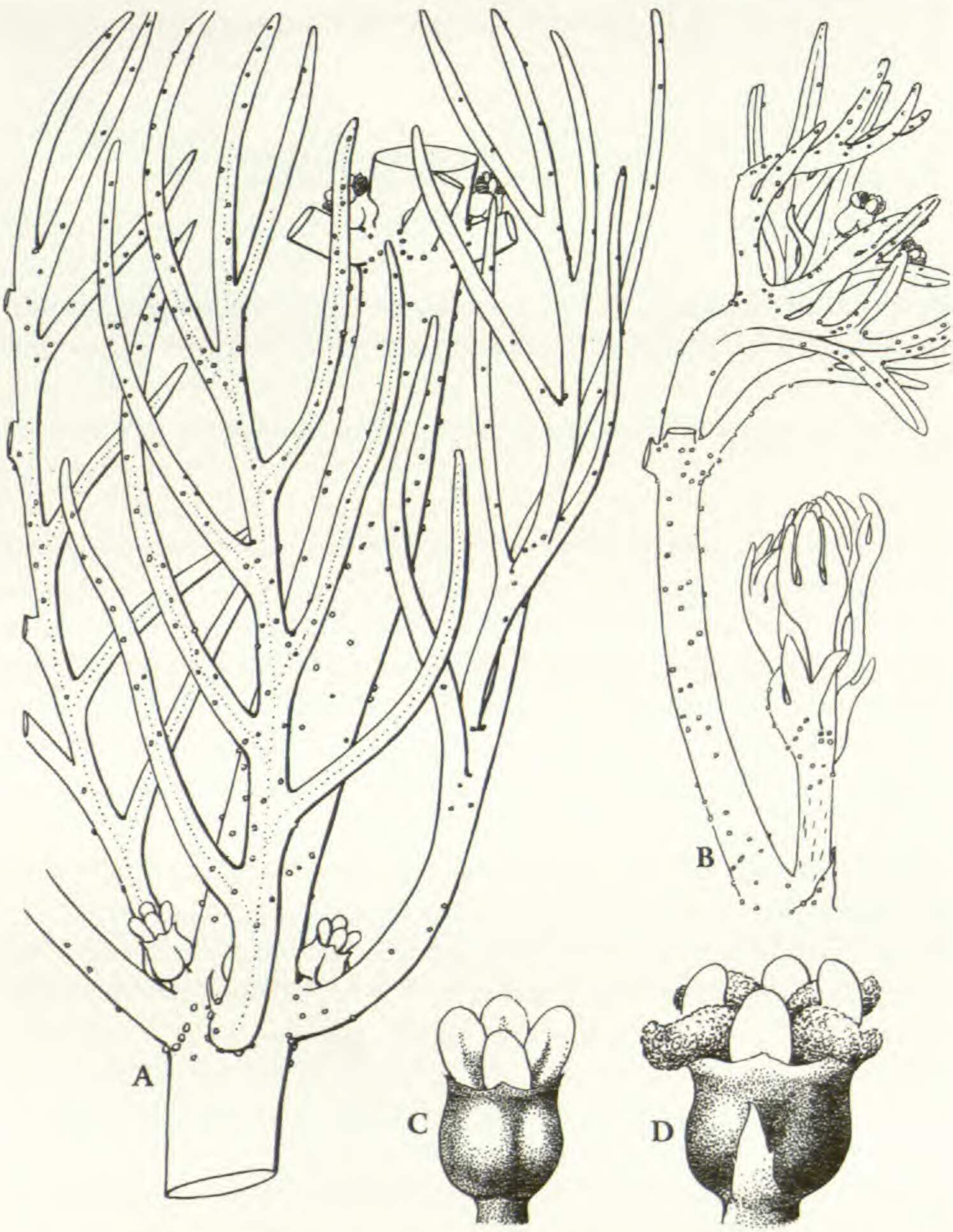

Figure 4. *Myriophyllum mattogrossense* drawn from submersed growth form specimens. (A) Section of stem showing axillary flowers, glandular emergences (appearing as dots) scattered on leaves and stems, and hydathodes present at leaf bases. (B) Section of young shoot. (C) Young flower with only stamens evident. (D) Mature flower with stigmas alternating with stamens, and with subtending bracteole present.

the description for the species. These features were, in particular, the presence of filiform "hydathodes," the *trichomas collectores* of Hoehne (1915), at the bases of the petioles and at the base of each leaf segment on young growth; the presence of numerous, scattered, globular sessile glands on the surface of the young stems and leaves; and flowers with a complete absence of a perianth. The Bolivian material is consistent with all of these features with exception to that of the perianth. In the Bolivian specimens the flowers do possess a single, 4-merous perianth whorl of small triangular appendages, arranged alternate the styles and opposite the 4 stamens, the stamens developing first and not persisting. A further character we noted was the presence of a pair of bracteoles subtending the flowers (Figure 4), which apparently are caducous, as they were noted only with earlier stages of flowers. *Myriophyllum mattogrossense* had previously been described as lacking bracteoles (Orchard 1981; Orchard and Kasselmann 1992); a lack of bracteoles is unusual in the family (Orchard and Kasselmann 1992).

The presence of sessile glands is unusual in the genus (Orchard and Kasselmann 1992), thus the feature can serve as a good diagnostic character for *Myriophyllum mattogrossense*. Since glands had not been noted on the Peruvian material (Orchard 1981), we re-examined the Peruvian herbarium specimens; globular sessile glands are, indeed, present.

Recently, some puzzling reports of *Myriophyllum mattogrossense* in the Gran Pantanal of Mato Grosso, Brazil, have appeared in the literature. Prado et al. (1994) noted that *M. mattogrossense* forms "luxuriant beds" during the high water stages in the Pantanal. This species was said to "bloom intensively" during this time, and then to die off. The authors stated that *M. mattogrossense* is "easily recognized in the field by its deep red, densely clustered leaves," and further noted that the species possesses emergent flowers which descend below the water's surface following fertilization (Prado et al. 1994, p. 581). Clearly, red vegetation and emergent inflorescences are characters not known to be associated with *M. mattogrossense*. Unfortunately, the identity of their plants cannot be confirmed as no voucher specimens had been cited.

Heckman (1997) reported *Myriophyllum mattogrossense* as filling the niche of submersed plants in the tropical wet-and-dry climatic zone in South America. In a subsequent book on the

Brazilian Pantanal, he described "luxuriant submerged beds" of *M. mattogrossense* that form in the northern Pantanal during the high water stage, and included a color photograph of the presumed *M. mattogrossense* (Heckman 1998). Having examined this photograph, we have concluded that the species in question is clearly not *M. mattogrossense*.

Although Pott and Pott (1997) included *Myriophyllum mattogrossense* in their comprehensive checklist of aquatic plants of the Brazilian Pantanal, they noted that they have never observed this species in the Pantanal, and were aware of its presence only through the original type collections of Hoehne (Vali Pott, pers. com., 1998). Furthermore, Guarim Neto's (1992) checklist of angiosperms of the Pantanal includes no species of *Myriophyllum*. In like manner, during our extensive expedition in 1998 in the Bolivian portion of the Pantanal we encountered neither *M. mattogrossense* nor any other species of *Myriophyllum*.

SPECIMENS EXAMINED

Bolivia. Department of Cochabamba: Province of Carrasco, road between Comunidad Ivirgarsama and Puerto Villarroel, ca. 18.5 km south of town, 16°59′08″S lat., 64°49′20″W long., elev. ca. 200 m, rooted among rocks in fast-moving water in the Arroyo Magareños, just below where it crosses the road, 19 Mar 1995, *Ritter 1678*; 8 Jun 1995, *Ritter & Crow 2313* (aquatic form); 8 Jun 1995, *Ritter & Crow 2314* (terrestrial form; LPB, MO, NHA).

Bolivia. Department of Cochabamba: Province of Carrasco, Arroyo Zabala, just below where it crosses the highway to Santa Cruz, 17°06′S lat., 64°40′W long., elev. ca. 230 m, rooted among cobbles and gravel in clear, fast-moving water, 5 May 1996, *Ritter 3147* (LPB, MO, NHA).

Brazil. Mato Grosso, near Cuyabá. Original specimens of F. C. Hoehne apparently lost (Orchard 1981). LECTOTYPE: Tabula n. 127 ("Ns. 4.578 e 4.635. Hab. lacus temporarius ad Coxipó da Ponte, propre Cuyabá"), Comm. Linh. Telegr. Mato Grosso Amaz., Annexo 5, Bot. 6. 1915.

Ecuador. Río Coca, 8 Feb 1990, *Kasselmann 133* (B). According to Orchard and Kasselmann (1992) the site locality is: Río Yanaucu (lower Río Coca drainage) about 20 km north of the town of Coca (Pto. Francisco de Orellana) at the crossing of the road from Coca to Lago Agrio.

Peru. Department of San Martín: Province of Mariscal Cáceres, al oeste de vivero del Instituto Agropecuario de Tocache, Tocache Nuevo, elev. 400 m, 10 Nov 1969, *Schunke V. 3598* (GH, US).

Peru. Department of San Martín, Province of Mariscal Cáceres, Fundo Jeroglífico, del Sr. Luís Ludeña (Quebrada de Ishichimi), Tocache Nuevo, elev. 400 m, 10 Apr 1975, *Schunke V. 8281* (MO).

Peru. Department of San Martín: Province of Mariscal Cáceres, Quebrada Ishichimi, cerca al Fundo del Sr. Luis Ludeña, sumergida en las riachuelos, elev. ca. 400 m, 3 Nov 1980, *Schunke V. 12393* (MO).

In order to facilitate differentiation of the species of *Myriophyllum* in South America the following key is provided, including information from our expanded understanding of *M. mattogrossense* and *M. quitense* (Ritter and Crow 1998). Additionally, it is noteworthy that although *M. spicatum* L. has been listed for Peru and *M. verticillatum* L. has been listed for Chile, specimens bearing those names were based on misidentified specimens (Orchard, 1981); these two species are not known to occur in South America.

KEY TO THE SOUTH AMERICAN SPECIES OF *MYRIOPHYLLUM*

1. Submersed leaves in whorls of (2–)3–4(–5); segments of submersed leaves very slender, distinctly flattened, ca. 0.5 mm wide, with conspicuous midvein, or filiform; emergent leaves absent on submersed form in reproductive phase (terrestrial growth form, with ascending aerial branches sprouting from prostrate stems, may be expected to occur stranded along water margin; leaves pectinate, mostly 10–11 mm long, segments mostly 3 per side); leaves and stems bearing scattered, small, globular, sessile glands (especially young material); flowers solitary, borne axillary along submersed portion of stem, (also axillary along erect stems on terrestrial form); flowers bisexual; stamens 4; mericarps with a few weak tubercles on outer surface; rare, lowlands, Ecuador, Peru, Bolivia, and Brazil .... *M. mattogrossense*

1. Submersed leaves in whorls of (3–)4–6; segments of submersed leaves filiform to only somewhat flattened, mostly up to ca. 0.25 mm wide, midvein not conspicuous; emergent leaves present on submersed form (terrestrial form rare in *M. quitense*; ascending aerial branches sprouting from prostrate stems, leaves pectinate, mostly 7–10 mm long, segments 5–6(–8) per side); leaves and stems lacking glands; flowers in spicate inflorescences, borne in the axils of the emergent leaves only; flowers unisexual, plant monoecious or dioecious (bisexual flowers on terrestrial form in *M. quitense*); stamens 8; mericarps smooth on outer surface ..... (2)

2. Submersed leaves in whorls of (3–)4(–5), ovate in outline, 1–2 cm long, with 7–9 pairs of pinnae, segments nearly

filiform, somewhat flattened; emergent leaves blue-green, tinted red or purple, in whorls of (3–)4, ovate to oblong, more or less entire, at least in upper parts, toothed to pinnatisect in lower parts; plants monoecious (flowers bisexual in terrestrial form); Andes from Venezuela to Tierra del Fuego, e. Argentina, s. Uruguay, and Falkland Islands, disjunct (introduced?) in Mexico, nw. North America, P.E.I., Canada ..... *M. quitense*

2. Submersed leaves in whorls of (4–)5–6, oblanceolate in outline, (1.7–)3.5–4 cm long, with 12–15 pairs of pinnae (lower leaves decaying rapidly); distinctly filiform, terete; emergent leaves glaucous, in whorls of (4–)5–6, narrowly oblanceolate, pectinate, with (9–)12–18 pairs of pinnae; plants dioecious (female plants only in adventive populations); s. Peru, s. Bolivia, and s. Brazil south to c. Chile, n. Argentina, and Uruguay, introduced weed northward in Mesoamerica and e. and nw. U.S. ..... *M. aquaticum*

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